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# Proceedings of the Faraday Society

FOUNDED 1903.

TO PROMOTE THE STUDY OF ELECTROCHEMISTRY, ELECTROMETALLURGY,  
CHEMICAL PHYSICS, METALLOGRAPHY AND KINDRED SUBJECTS.

VOL. III.

MARCH, 1907.

PART 3.

## PROCEEDINGS OF THE TWENTY-SEVENTH ORDINARY MEETING.

The Twenty-seventh Ordinary Meeting of the Faraday Society was held on Tuesday, February 19, 1907, at the Institution of Electrical Engineers, 92, Victoria Street, S.W. Dr. T. Martin Lowry was in the chair.

Mr. John B. C. Kershaw, F.I.C., read a Paper entitled "The Present Position and Future Prospects of the Electrolytic Alkali and Bleach Industry."

The Paper opens with a brief historical review. The original patent of Charles Watt for the electrolytic production of sodium or potassium hydrate and chlorine compounds was taken out fifty-five years ago; but the earliest industrial experiments were made in the early eighties, and in 1889 a 200-H.P. plant was erected at Griesheim, using the "elektron" cell, in which the diaphragms are said to be made of cement. This cell is now used extensively on the Continent, and appears to work satisfactorily and economically.

In England the earliest industrial trials were made with an asbestos diaphragm cell at Snodland in 1891-92, and afterwards with a bell type of cell. These experiments led to the formation of the *Electrochemical Company* at St. Helens, but the works are now closed down. The Hargreaves-Bird and the Castner cells were patented in 1892-93; the Castner-Kellner Works were started at Runcorn in 1897.

In America a Le Sueur diaphragm cell was erected in 1892 and a Castner cell at Niagara in 1897-98.

The second part of the Paper contains a list of the works now operating in Europe and America, summarising, as far as information is available power used, type of cell and process employed, and products made. The totals show that about 55,000 H.P. are now being devoted to the production of alkalis and bleach by the electrolytic method, and that plant representing about 13,000 H.P. is lying in reserve. Assuming that all the plants are being worked to the best advantage, the production of 70 per cent. caustic soda at present would be about 110,000 tons per annum, with an equivalent of 100 tons of 35 per cent. bleaching powder (2 tons of caustic and 4.2 tons of bleach per E.H.P. year).

In conclusion the future of the industry is discussed. Within the last few years the electrolytic method appears to have had a set-back. In the author's opinion the Le Blanc, electrolytic, and ammonia soda processes will continue to be worked side by side. In the case of the first, alkali and bleach will be produced in diminishing quantities, but be compensated for by the sulphur  
I. PART 3.

derivatives which will yield the profits. The best of the electrolytic processes will gradually replace the Le Blanc method for the manufacture of chlorine products, and they will also produce metallic sodium and its derivatives. The ammonia soda process will continue to manufacture sodium carbonate and bi-carbonate, but it can never replace the other methods, until at any rate it succeeds in making chlorine products from its waste liquors.

**Mr. W. Pollard Digby** regretted that more information was not available regarding such points of detail as anode consumption, life and efficiency of diaphragms, &c., which would be of general use to those engaged in the smaller electrolytic industries.

**Mr. John Rhodin** gave some interesting details regarding the early history of the electrolytic processes. He demurred from the author's statement that these were principally developed in Germany, and he attributed the failures in this country to over-capitalisation and reckless finance, and not to any lack of skill or knowledge on the scientific side. The future will largely depend on the cost of power production.

**Dr. R. Seligman** drew attention to some omissions in the author's list of works and products.

**Dr. H. Borns**, referring to the lack of information regarding diaphragms, thought that magnesite was being used successfully.

**Mr. J. C. Richardson** also added some interesting historical information. He favoured the "bell" type of cell, in which an 84 per cent. efficiency was possible.

On the motion of the **Chairman** a cordial vote of thanks was accorded to the author for his paper. The reply to the discussion was reserved for the *Transactions*.

### OFFICIAL NOTICES.

The next **Ordinary Meeting** of the Society will be held on Tuesday, March 19, 1907, at the Institution of Electrical Engineers, 92, Victoria Street, London, S.W., when the following Papers will be read:—

"The Potential of Hydrogen liberated from Metallic Surfaces." By **H. NUTTON** and **H. D. LAW**, B.Sc.

"Electrode Potentials in Liquid Ammonia." By **F. M. G. JOHNSON**, M.Sc., and **N. T. M. WILSMORE**, M.Sc.

"The Impedance of Solutes in Solvents as manifested by Osmotic Pressure." By **JOHN G. A. RHODIN**, F.I.C.

"The Electrolytic Deposition of Zinc, using Rotating Electrodes." II. By **T. SLATER PRICE**, D.Sc.

### ANNUAL GENERAL MEETING.

Notice is hereby given that the Annual General Meeting will take place on Tuesday, May 28, 1907. The nominations for the Officers and Council to be elected will be announced at the Ordinary Meeting on Tuesday, March 19th.

### CHANGES OF ADDRESS.

|                          |                                                                                    |
|--------------------------|------------------------------------------------------------------------------------|
| <b>DOLPHIN, H. E.</b>    | Park House, Chester.                                                               |
| <b>HINCHLEY, J. W.</b>   | 15, Fawcett Street, Redcliffe Gardens, Bristol.                                    |
| <b>STANSFIELD, EDGAR</b> | Macdonald Chemistry and Mining Department,<br>McGill University, Montreal, Canada. |

### NEW MEMBER.

|                                        |                           |
|----------------------------------------|---------------------------|
| <b>F. W. HARBORD, F.I.C., A.R.S.M.</b> | 16, Victoria Street, S.W. |
|----------------------------------------|---------------------------|

## ABSTRACTS OF PATENTS

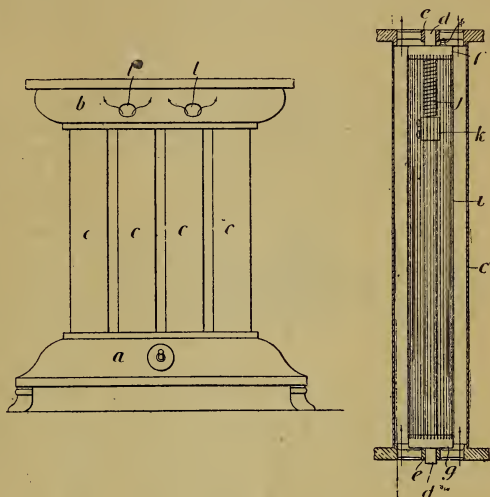
### RELATING TO ELECTROCHEMISTRY AND ELECTROMETALLURGY.

*Specially compiled by MESSRS. G. F. REDFERN & Co., Chartered Patent Agents, of  
4, South Street, Finsbury, E.C.; and 21, Southampton Buildings, London, W.C.*

#### BRITISH SPECIFICATIONS PUBLISHED.

**Apparatus for Heating Air by Electricity.**—S. O. COWPER-COLES, of Grosvenor Mansions, 82, Victoria Street, Westminster. No. 2,072 of 1906. The invention consists in making use of resistances of a known type, but of improved construction, in

which a tube or rod has mounted upon it, at a convenient distance apart, two insulating heads or caps, between which a wire is laced, the wire being maintained taut by means of a spring. In the improved form of resistance the wire forming the resistance is laced through holes or recesses in the two caps or heads of insulating material, such as porcelain, in such a manner that two concentric rows of the laced wire are obtained, forming a hollow cylindrical resistance having a double wall: *a* represents the hollow

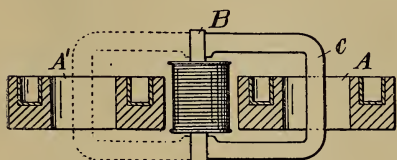


base of the heater and *b* its hollow top, *c, c* being a number of tubes mounted between the base and top. Each tube *c* is fitted with an electric resistance of such a diameter that a space is left between the outer surface of it and the inner surface of the tube. A convenient form of resistance comprises the rod *d*, mounted in supports *e* in the top *b* and base *a*, and the two porcelain heads or caps *f* and *g* mounted upon the extremities of the rod *d*. The caps *f* and *g* are made with the peripheral holes, and through these the wire *i* forming the resistance is laced, passing alternately through a hole in the cap *f*, thence down to the other cap *g*, through one of the holes *h* and up to the cap *f*, and so on until all the holes have been threaded and the resistance assumes the form of a double-walled tube. The two ends of the wire *i* are connected to the two terminals in connection with the current supply. The cap *f* is loose upon the rod *d*, and the wire *i* is maintained taut by means of the spring *j*, which is coiled around the upper end of the rod *d*, one of its extremities bearing against the under side of the upper porcelain cap *f*, and the other against the socket *k* fixed upon the rod. Another form of cap is made with annular recesses at different levels and notches which divide the periphery into a number of teeth, over which the wires are passed, so as to provide the double-walled tube of laced wire as above described. With a heater thus made, the air

passes into the lower ends of the tubes *c*, is heated, and flows rapidly upwards through the annular spaces provided between the tubes and the resistance coils; fresh air being simultaneously drawn in at the open lower ends of the tubes. The heated air passes into the hollow top *b*, and thence escapes into the surrounding atmosphere through the orifices *i, i* in the top *b*. As the air flows up the tubes *c* with considerable velocity, their surfaces are maintained comparatively cool. Electric lamps may be connected up in the circuits so that the apparatus provides illumination in addition to heat.

**Process of Treating Sheet Metal and Depositing Metallic Coatings thereon by Electrolysis.**—HILLE and MÜLLER, of Porschdorf, near Schandau, Saxony. No. 9,434 of 1906. Instead of suspending sheets for electrodeposition separately in the bath, they are connected by clips, solder, screws, or otherwise, so as to form a band, in which form they are passed through the bath continuously and uniformly coated.

**Electric Furnaces.**—A. HIORTH, of 19, Josefinegade, Christiania, Norway. No. 28,370 of 1906. The invention has reference to induction smelting furnaces, and its object is to provide for heating two or more of

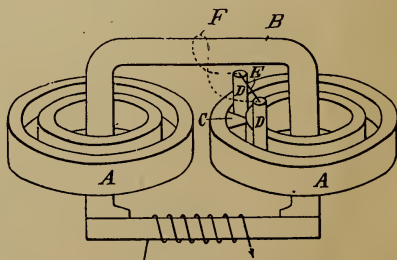


such furnaces by a single magnet core, so that one or more may be at work whilst another is undergoing repairs. *A* indicates a furnace of this kind heated by means of the transformer, comprising a core *B* and yoke *C* detachable one from the other,

so that they can be disconnected, and the yoke taken out and secured in the position indicated by dotted lines, where it may serve for heating the furnace *A'* whilst the furnace *A* is idle for any purpose. The core may be provided with several yokes, each serving to heat its furnace, then any of them could be detached to put its furnace out of work. In these furnaces, as at present constructed, it is necessary at starting to provide them with a ring of conducting metal, specially prepared to act as initial circuit for the induced current; but with furnaces constructed by this invention it is only necessary to take a charge directly from an adjacent working furnace.

**Method of Operating Electrical Smelting Furnaces.**—A. HIORTH, of 19, Josefinegade, Christiania, Norway. No. 28,959 of 1906. According to

this invention transformer furnaces are adapted for use as melting furnaces as well as for refining. To this end, when the furnace is used for extraction, a removable partition *G* is interposed in the annular channel of the furnace, also a pair of electrodes *D, D* which dip into the slag only. Then the circuit is completed through *E*, and the current passes through the badly conducting slags. *F* indicates a secondary coil

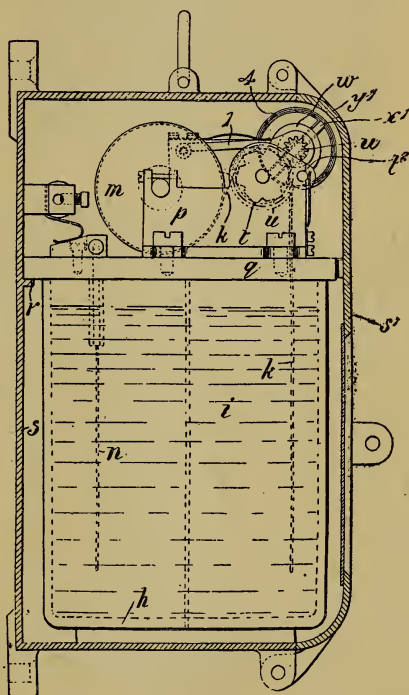
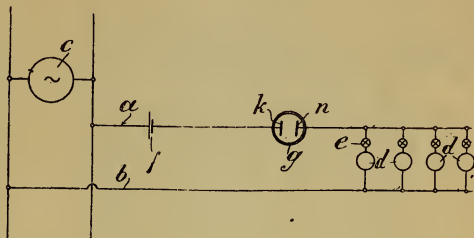


that may be used instead of a direct connection *E*. Or, the electrodes *D, D* may be in a single piece like a horse-shoe, and be oscillated up and

down to give an undulating movement to the mass under treatment. The partition *C* may have a narrow passage for the charge.

**Electricity Meters.**—W. M. MORDEY and G. C. FRICKER, both of 82, Victoria Street, Westminster. No. 1,963 of 1906. Relates to electrolytic

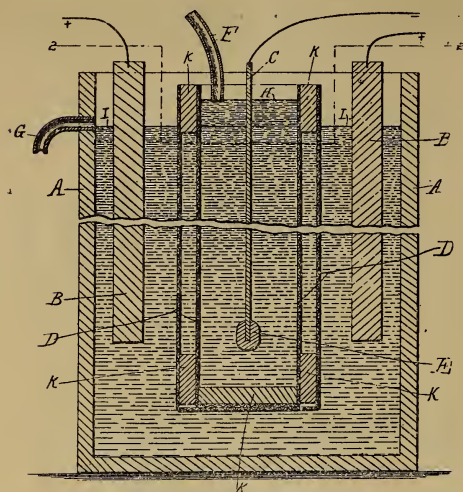
means for metering alternating currents, and consists in inserting in the alternating current circuit *a*, *b* a source of small direct current *f* and a depositing cell *g*. The invention is especially adapted for prepayment purposes. When the immersed portion of the anode is dissolved by the direct current the whole circuit is interrupted automatically, and a further supply of anode must be fed in. The predetermined supply of current is thus a direct linear function of the anode immersed. In the prepayment meter *g* the anode *k* is a thin strip of copper ribbon wound on a drum *m*. The cathode *n* is a copper plate. In exchange for a coin inserted at *y'* and passed into the slot *x'*, a length of anode strip *k* can be wound by gearing *u* from the drum *m* into the electrolyte *i*. Then the immersed portion of the anode is dissolved by the direct current, whose strength will be dependent on the number and conductivity of the devices *d* in use, although the alternating current has no electrolytic action on the anode. In a modification of



the invention a primary cell of the Daniel type is introduced into the circuit and used to produce the small direct current as well as to meter the alternating current. The zinc electrode is a thin ribbon fed by prepayment mechanism in the manner described above.

**Process of Separating Metals.**—N. V. HYBINETTE, of Westfield, Union City, N.J., U.S.A. No. 25,122 of 1905. If a copper-nickel matte is roasted and leached with sulphuric acid, practically only copper is removed until the residue contains nickel and copper in the proportion of three to one; and if a copper-nickel alloy is electrolysed, the nickel is deposited from the anode more rapidly than the copper, so that the falling slimes are mainly copper compounds. If sulphur is present in the anode, the anode slime will

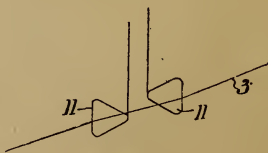
be copper sulphide. By combining these processes the inventor is able to obtain such proportions of nickel and copper that the latter can be commercially eliminated by passing



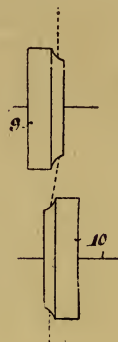
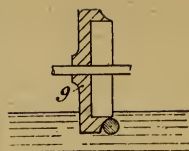
it off as an impurity through a solution of nickel which is regenerated. The electrolyte *I* is a solution of nickel sulphate with a small proportion of weak organic acid such as phosphoric, boric, or lactic, the solution preferably being so dilute that it will not crystallise at ordinary temperatures. *B, B* are anodes of the copper-nickel alloy to be decomposed, and *C* is the cathode of copper about 0.10 to 0.15 in. thick, prevented from warping by the wooden frame *E*. The electrolyte is kept in movement at right angles to the electrodes through a bag-diaphragm, or filter *D* of canvas

of such mesh as will allow a head *H* of about 1 in. to be maintained in it, the supply being from pipe *F* and the overflow at *G*. The resistance of the bag is practically *nil*, and the plating is effected as if there were no diaphragm, except that an equivalent of nickel is deposited on the cathode within the bag and an ion of sulphuric acid left free. The latter decomposes the molecule nearest, and so on, the final exchange causing an ion of  $H_2SO_4$  to be liberated at the anode, and at the same moment an ion  $Ni$  is deposited at the cathode. The ion of  $H_2SO_4$  immediately causes an ion of  $Cu$  or  $Ni$  to be dissolved in the solution, and these ions travel towards the cathode, but the movement is counteracted by the current through the bag and the ions cannot pass. A constant flow of nickel sulphate solution containing 40 grammes of nickel per litre is fed to the bag and, although plating is continuous, the bag is not deprived of its nickel. The electrolyte overflowing at *G* is regenerated by cementation, first being maintained at a boiling temperature in contact with slabs of nickel alloyed with 30 per cent., say, of copper. Here the copper is largely cemented out, its place being taken by an equivalent of nickel. The solution is then placed, under the same conditions, in contact with slabs of pure nickel, where the last traces are eliminated. The solution is next electrolysed to oxidise the iron which is converted from  $FeO \cdot SO_3$  to  $Fe_2O_3 \cdot 3SO_3$ , the current employed being 1 to 2 amps. per square foot. Insoluble anodes of platinum or carbon are used. The solution is then charged with nickel carbonate to excess and the iron precipitated as iron carbonate, from which the solution is filtered for re-use in the tank *A*.

**Electroplating Apparatus.**—A. SCHMITZ, of 103, Kantstrasse, Charlottenburg, near Berlin, Germany. No. 1628A of 1906. The invention relates to an alternative to the method of collecting the current to that described in the specification immediately following, No. 1,628 of 1906.



Instead of rollers, contact wires *II*, *II* are employed, which are pressed against the sides of the wire or ribbon 3, being electroplated to collect the current at short intervals, and so allow the use of high intensity currents.

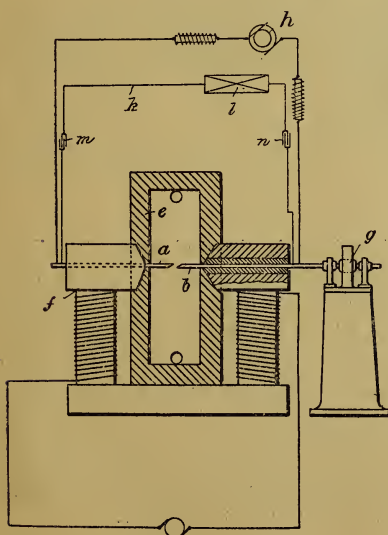


**Electroplating Apparatus.**—A. SCHMITZ, of 103, Kantstrasse, Charlottenberg, near Berlin, Germany. No. 1,628 of 1906. Relates to means for electroplating or galvanising wire, metal ribbon, &c., when using currents of high intensity in order to obtain rapid deposition. In order to allow of this the wire is drawn through the baths at high speed, and the current collected from it at short intervals by rollers 9 and 10 having curved contact surfaces which touch the wire only on its side where the deposit is thickest. These rollers 9 and 10 are mounted on arms pivoted on cathode bars, so that they are adjustable automatically, and the electrolyte level is only a little above the contact surfaces, so that deposition upon the wheels 9 and 10 is largely prevented.

# UNITED STATES PATENTS ISSUED.

**Electric Furnace.**—K. BIRKELAND and S. EYDE, both of Christiania, Norway. No. 837,277. The invention relates to electrical furnaces of the

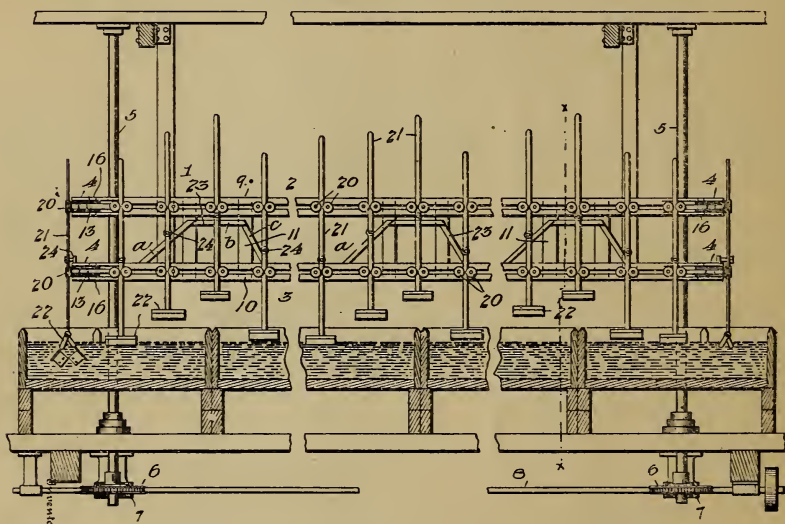
kind in which an arc dispersed by a magnetic field is made use of, and the object is to so improve them that they may be advantageously run with alternating currents, also to make it possible to increase the ratio between the tension of the furnace and that of the electric machinery. It is observed that extinction of the arc always takes place when the current is about zero, and if extinction could be avoided at this point the tension might be materially increased. This increase is obtained according to the invention by interposing a resistance in the arc which alternates in synchronism with the current phase and in such a way that the resistance is at its minimum when the current is passing zero. The upper figure is a diagram of the current curve produced. The resistance may be set up in various ways; in one method, *a* and *b* are the electrodes, shaped as shown, and one of them, *b*, rotated synchronously with the current phases by means of a synchronous motor *g*;



*f* is an electromagnet arranged to create a field in the furnace around

the electrodes. Sometimes tubular electrodes, having serrated ends so as to give a number of points, are employed and are rotated by a synchronous motor having a corresponding number of poles. By another arrangement the electrodes are stationary and have rotating between their points a pointed arc former by which the resistance is varied. It is possible to obtain the desired result with a pulsating magnetic field, the pulsation having an effect on the factor of energy equivalent with the variation of distance between the electrodes. Again, the result may be obtained by what the inventors term an "electrical method." The electrodes are connected with an auxiliary circuit *k* applied from source *l* through condensers *m, n* producing a spark discharge of high frequency with high tension and low current strength. Such discharges may act as a bridge for the working arc.

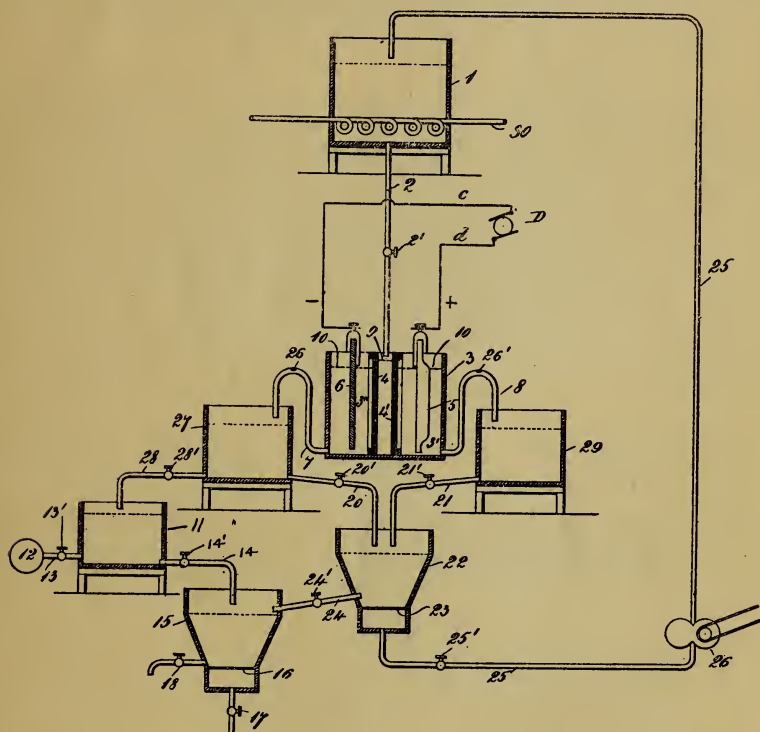
**Dipping Mechanism for Electroplating Apparatus.**—D. F. BRODERICK, of New Britain, Ct., U.S.A. No. 839,719. The invention relates to mechanism for immersing articles in successive baths, in each of which a stage of the electroplating process is completed. The articles to be plated are held by carriers 22, affixed to rods 21, carried by rollers 24 which run upon a track. The carriers, rods and rollers, and the articles to



be treated are impelled along the track, which is situated above two lines of baths, by means of two endless chains 13, 13 engaged at each end by sprocket wheels 4, 4 on shafts 5, 5 having worm wheels 6, 6 which engage worms 7, 7 on the shaft 8. Both chains 13, 13 are provided with links at intervals, each having a pair of rollers 20 for guiding the rods 21 vertically. These rods 21 and the articles which they carry during treatment are raised from the successive baths by inclines *a* up which the rollers 24 are forced by the movement of the chains 13, 13, and having mounted sufficiently high to clear the bath end walls, they travel over them along a straight track *b* and then descend inclines *c*, so as to lower the articles into the succeeding tank, and so on, until the series of dipping operations is complete.

**Art of Producing Pigments by Electrolysis.**—E. D. CHAPLIN, of Boston, Mass., U.S.A. No. 836,177. Relates to the production of white

lead. A soluble salt of lead is first precipitated to form lead hydrate, and this is carbonated to produce white lead. The supply tank 1 contains an electrolyte which is separable by means of an electric current into a solvent of lead and an alkaline hydrate—for example, an aqueous solution of an alkaline base containing also an aqueous solution of a chloride or chlorate of an alkaline base. When the electrolyser 3 is charged with the neutral solution and the current passed through it, a soluble acid lead salt is formed in the chamber 3', containing the lead anode 5, and an alkaline hydrate—in this case sodium hydrate—is formed in the cathode chamber 3''. It is thought that lead hydrate is first formed in anode chamber 3' and is converted into a lead chloride which is soluble at the temperature maintained by the steam-coil 30, and finally is converted into

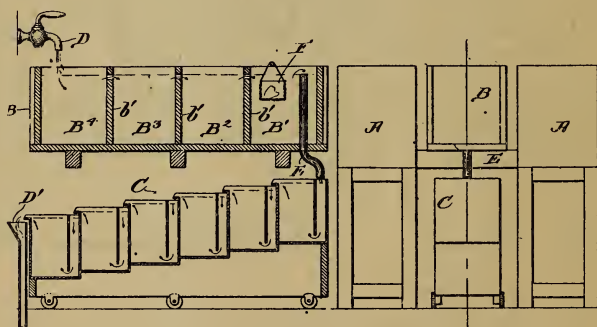


lead oxychloride which is soluble at ordinary temperatures. The last-named salt, being acid, renders the formation of insoluble basic salts impossible. 4 and 4' are foraminous diaphragms, and the electrolyte is caused to flow continuously through the electrolyser 3 by keeping the liquid level between them above that in the anode and cathode chambers. These latter both empty through pipes 7 and 8, each provided with holes 26 and 26' to prevent siphoning. The acid lead salt solution and the alkaline hydrate after passing through settling tanks 29 and 27 respectively are mixed in tank 22, and lead hydrate is precipitated from the acid salt and the filtrate is pumped back to tank 1. A portion of the alkaline hydrate from the chamber 3'' is converted in tank 11 into sodium bicarbonate by treating it with  $\text{CO}_2$  produced at 12. The lead hydrate from tank 22 is discharged into tank 15 to which the

sodium bicarbonate from tank *II* is also conveyed and the lead hydrate converted into lead carbonate, which settles at the bottom and is drawn off for use at *17*.

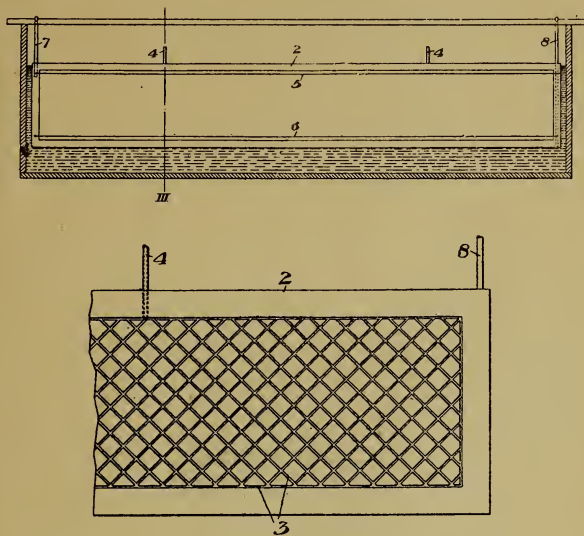
**Solution for Use in Art of Electrotyping.**—A. GERSTNER, of Brooklyn, N.Y., U.S.A. No. 838,977. The object of the invention is to reduce the number of steps at present required in the production of electrotypes. Instead of leading, polishing, blowing, washing, dipping in sulphate of copper, sprinkling on iron filings, and then washing the mould in sulphate of copper, by this invention the wax mould is simply sprayed with a solution composed of nitrate of silver, 1 oz.; chloride of sodium, 2 ozs.; graphite (moulding-lead), 2 lbs.; water, 1 gallon. By this means a thin coating of chloride of silver is formed on the mould which combines with the copper in the plating solution to form a metallic silver coating.

**Process of Electroplating.**—W. S. HUTCHINSON, of Boston, Mass., U.S.A. No. 838,717. In electroplating it is necessary thoroughly to wash the plated articles, after deposition, in order to remove the adherent solution, and when this is done in the usual way great loss of metallic constituents is incurred. In electroplating with gold it is especially desirable to reduce this loss, and in order to effect a thorough rinsing of the articles, and also save all the valuable residues, the inventor arranges, between the plating tanks, a rinsing tank *B*, divided into compartments *B'*, *B<sup>2</sup>*, *B<sup>3</sup>*, *B<sup>4</sup>*, the last, *B<sup>4</sup>*, being fed from a supply *D*, and overflowing into *B<sup>3</sup>*, which overflows into *B<sup>2</sup>*, and so on. The plated articles are first rinsed in tank *B<sup>2</sup>*, then in *B<sup>3</sup>*, and next in *B<sup>4</sup>*. By this means the minimum amount of water is used



for the purpose, so that the solution in *B'* can be advantageously treated for recovery of the values. In the method described for this treatment the concentrated solution overflows down the pipe *E*, and passes through a series of boxes *C* containing zinc shavings. The chemical reaction in the recovering boxes results in the disintegration of the zinc and the formation of a slime or mud, from which the gold can be readily extracted. If the solution in the compartment *B'* is not sufficiently concentrated the gold is sometimes plated on the zinc, a form not best suited to final recovery. To obtain the required concentration a perforated basket *F* is suspended in the tank *B'* to contain potassium cyanide for enriching the solution and ensuring the precipitation of the gold as slime.

**Method of Electroplating.**—E. L. LIVINGSTONE, of Munhall, and W. F. McNULTY, of Allegheny, Penn., U.S.A. No. 838,346. The invention relates chiefly to the electroplating of wall-paper and the like. The paper to be plated is laid upon a board 2, having a number of grooves 3, 3, on its face, these grooves being connected to an exhausting pump through pipes 4. The paper is sucked down flat by these means, and is then coated with an adhesive



varnish to prevent absorption of any of the electrolyte. Afterwards the graphite, or metal powder, is applied in any suitable manner, and two wires, 5 and 6, extended along the edges of the paper, as shown, to distribute the current entering at the supports 7 and 8. The board is then lowered into the plating-bath and the electro-deposition effected in the usual way. The coating is stated to be effected very rapidly and uniformly, whilst the suction system prevents any warping or buckling.

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# Proceedings of the Faraday Society

UNIVERSITY OF ILLINOIS  
URBANA

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CHEMICAL PHYSICS, METALLOGRAPHY AND KINDRED SUBJECTS.

VOL. III. JANUARY & FEBRUARY, 1907. PARTS I AND 2.

## PROCEEDINGS OF THE TWENTY-FIFTH ORDINARY MEETING.

The Twenty-fifth Ordinary Meeting of the Faraday Society was held on Tuesday, January 15, 1907, at the Institution of Electrical Engineers, 92, Victoria Street, S.W. Sir Joseph Swan, F.R.S., Past-President, was in the chair.

Mr. E. E. Fournier d'Albe read a paper and opened a general discussion on "The Application of the Electron Theory to Electrolysis."

The electron theory by postulating the existence of material carriers of all electric charges, is practically an extension of the ionic theory to solids and gases, and it thus brings into line the processes of metallic and electrolytic conduction. In both cases the conductivity of a body is defined by the number of ions (in the wide sense) it contains in unit volume and by their average mobility; in a cm.-cube of copper, for example, a current is conveyed by some four hundred trillion free electrons, in a cm.-cube of milli-normal hydrochloric acid the current is conveyed by some two trillion hydrogen and chlorine ions. In a 1 mm. copper wire carrying 1 ampere the electrons will move at about 1 cm. per second.

It is not yet clearly understood why free electrons should be observed in a vacuum and a metal, but that there should be none in a liquid. It is supposed, however, that it is the close packing of the metallic atoms which renders possible a frequent exchange of electrons between one atom and another, and while free the electron is able to fall along the potential gradient and thus constitute a current. In an insulator the electrons are effectively bound up with the atoms or molecular groups; in an electrolyte mobile charged groups are formed, which can follow the E.M.F. Free electrons are not formed on account of the unequal attractions for these displayed by the positive and negative atoms of the solute. Thus in an HCl solution, when two atoms of a molecule separate, the hydrogen atom will lose an electron and become positively charged, while the chlorine atom will gain one and become negatively charged. These ions will act as condensation nuclei, gathering molecules of the solvent around them and becoming "hydrated." The expenditure of energy involved facilitates the condensation, which explains the low mobility of the ions and the variability of the same, the drop of potential at the electrodes, and the liberation of uncharged products. The E.M.F. is unable to drive the hydrated ions into the closely packed atoms of the electrodes, but if it exceeds a certain minimum it is able to drive electrons in or out, as the case may be, and the constituent elements of the ions then

VOL. III. PARTS I AND 2.

lose their condensing powers, drop the water molecules, and are thus liberated as uncharged atoms.

The author draws attention to the importance of making further studies of mobility and quantitative determinations of the hydration of ions as a preliminary for determining the sizes of the ions and of their actual constitutions based on kinetic principles. It is possible that the motions of heavy ions may be actually observed in an ultra-microscope. The future development of electrolytic theory will lie, in the author's opinion, in the direction of statistical analysis of these motions of the ions through the electrolyte and into the electrodes, after the fashion of Thomson's "counting experiment," and in the complete determination of the energy transformations at each stage.

**Mr. John G. A. Rhodin** considered that the electron theory, like the atomic theory, merely complicated matters, and was unnecessary. The conception of infinite divisibility was a necessary one in physics as in mathematics, if our reason was to be satisfied. Both in chemistry and physics we know of mathematical relations only, and hypotheses are only crude images. The ether and electrons were invented because certain phenomena could be the more easily treated mathematically by means of these conceptions. A simple theory of ions was all that was necessary for understanding electrolysis; more hypotheses were not wanted. Existing theories left many well-known facts without explanation. He suggested the appointment of an International Committee for generalising existing theories and making them available to the average intelligence.

**Dr. H. Borns** asked whether the Hall effect and the recent experiments of Kaufmann did not throw some doubt on the electron theory. Why were there no free electrons in liquids?

**Dr. J. A. Harker** was not clear as to whether the theory supposed atoms to be composed entirely of electrons or whether there were a central nucleus. If the former, one would expect more intermediate formations. He thought the fundamental conceptions of the theory should be made perfectly clear, so that the explanations of various phenomena given by it could be deduced from some simple postulates.

**Dr. T. M. Lowry** pointed out that much of the work on hydration asked for by the author had been carried out, among others, by Biltz, Jones, and Bousfield. The latter had shown, for example, that the chlorine ion attached five water molecules to itself.

**Mr. N. T. M. Wilsmore** considered that the theory, which looked upon electrons as exerting a sort of osmotic pressure at the surface of an electrode, conceived admirably the mechanism of electrode potential and of electrode reactions. It was noteworthy that the more electro-positive a metal, the more easily it threw off electrons under the stimulus of ultra-violet light, for example. He showed how the theory explained, in a simple manner, oxidation and reduction phenomena and the action on the positive accumulator plate. He thought that the negative electron should have a distinctive name, and proposed using the word "negatron," which had been suggested.

**Mr. F. Kaye** remarked on the simple explanation of the different mobilities and therefore hydrations of the various ions on the view that the positive and negative ions acted to different degrees as condensation nuclei. He asked whether when a liquid was evaporated there was a movement of electrons into the vapour.

**Mr. F. S. Spiers** pointed out that the theory did not seem to help in explaining the fundamental preliminary to electrolysis, namely, dissociation in solution.

**Mr. E. E. Fournier d'Albe** replied to the various speakers. He did not think that the few considerations put forward by Mr. Rhodin overthrew the theory. The difficulty of the Hall effect mentioned by Dr. Borns was more serious, but the negative swing that had been observed might be due to positive ions of great mobility, and not necessarily to the existence of positive electrons. A similar recent observation of the Faraday effect could be similarly explained. Kaufmann's experiments dealt with structure of electrons and merely pointed to Abraham's theory of a rigid electron being more probable than Lorentz's, which, in order to account for the Michelson-Morley experiments, supposed the electron to become shortened in its passage through the ether. Their great mobility in face of little resistance would prevent free electrons existing in liquids. When a metal was liquefied, probably polymerisation took place, and ions were formed which carried the current.

In reply to Dr. Harker, it seemed that atoms most likely consisted of negative electrons whirling round a positive nucleus. The solar system presented a close analogy. Only certain configurations would be stable, hence every intermediate stage of element would not persist. The theory at present could not be built up from simple postulates; it was in the induction stage, and kept in close contact with facts.

In reply to Mr. Kaye, electrons did not pass into the vapour from a boiling liquid; the surface of the liquid was a perfect semi-permeable membrane.

**The Chairman**, in moving a vote of thanks to the author for his important and interesting paper, which had stood so well the trying ordeal of some trenchant criticism, referred to the inadequacy of the old ideas to account completely for all the phenomena of conduction, electrolytic and other, ideas which he none the less found it not easy to get rid of without at least some further consideration.

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#### PROCEEDINGS OF THE TWENTY-SIXTH ORDINARY MEETING.

The Twenty-sixth Ordinary Meeting of the Faraday Society was held on Tuesday, January 29, 1907, at the Institution of Electrical Engineers, 92, Victoria Street, S.W., when a General Discussion on **Osmotic Pressure** took place. Professor H. E. Armstrong, F.R.S., was in the chair.

The discussion was opened by the **Earl of Berkeley**, who exhibited and described his "Apparatus for the Direct Measurement of Osmotic Pressure."

The ordinary direct method of measuring osmotic pressures is to obtain equilibrium on the two sides of the semi-permeable membrane by means of the pressure of a head of liquid. The method devised by the author and Mr. E. G. J. Hartley substitutes mechanical pressure, which is put straight on to the solution, and equilibrium thus obtained. Reversing the usual arrangement, the solution is put outside the semi-permeable tube, in an outer containing tube of gun-metal, and the solvent inside, suitable mechanical

arrangements being provided for rendering the joints leak-tight. The pressure is obtained from a plunger worked with a pile of weights and delivered through a mercury U-tube to the solution outside the septum. Equilibrium is obtained or calculated by watching through a telescope the motion of the solution in a gauge. The measurements may be made at any desired temperature. Corrections are applied for the imperfect semi-permeability of the membrane by analysing the solvent to see if any solution has passed into it.

A vapour-pressure method for measuring osmotic pressure was also described. This is a modification of the Ostwald and Walker dynamical method. Air is sucked through a spiral train of glass vessels containing first sulphuric acid, to dry it, then the solution from which it gets saturated up to the vapour pressure, then the solvent, of which it here takes up more, and finally sulphuric acid again. There are two trains of vessels arranged to oscillate about a central axis, so that the air does not actually bubble *through* the liquids, which is unsatisfactory, but merely passes *over* them, glass beads being placed in the tubes to increase the wetting surfaces. The whole apparatus can be placed in a bath and worked at any desired temperature. Arrhenius' relation was used for calculating the osmotic pressures from the lowered vapour pressures, and very concordant results were shown to have been obtained between measurements made by the direct-pressure and the vapour-pressure methods. The author is of opinion that the latter method will chiefly have to be relied upon to furnish accurate data for the further study of osmotics.

**Mr. W. C. Dampier Whetham, F.R.S.**, speaking on "Indirect Methods of Measuring Osmotic Pressure," agreed as to the importance of the vapour-pressure method. He discussed the formula used by Berkeley and Hartley, and explained the difference between it and the van't Hoff formula obtained from thermodynamic considerations, the expressions being identical where there is no change of volume of the solvent as it enters the solution.

**Dr. T. M. Lowry** spoke on "Osmotic Pressure from the Standpoint of the Kinetic Theory." The motion of the particles postulated by the kinetic theory leads in the case of composite gases or liquids to a process of diffusion. When diffusion is resisted a pressure is set up which constitutes the osmotic pressure of the system. This can be effected by means of a semi-permeable membrane, through which only one of the constituents can pass. Such membranes undoubtedly act in virtue of their solvent properties.

The application of the equation  $PV = RT$  to the osmotic pressure of gases could be predicted on general theoretical grounds, but there was no *à priori* reason for supposing that it would be applicable to the case of liquids. The mere fact that all liquids were not miscible was sufficient to show that the conditions were widely different from those prevailing in mixed gases. The validity of the law had been established experimentally, and must be accepted as a fact of fundamental importance in all discussions as to the nature of osmotic pressure.

In the early years of the osmotic discussion it had been assumed by van't Hoff and others that since osmotic pressures and gas pressures could be calculated by means of the same formula the conditions must be identical in the two cases, and it was definitely stated that in dilute sugar solutions the osmotic pressure was wholly due to the bombardment of the membrane by the molecules of the sugar, the effects produced by the water molecules being substantially identical on either side of the membrane. The alternative view, that osmotic pressure represented a diminution in the activity or "active mass" of the solvent was suggested by Poynting in 1896, and had subse-

quently been advocated by Armstrong, Beilby, van Laar, and others. In most cases it had been assumed that the essential factor was a diminution in the average energy of the water molecules. From the standpoint of the kinetic theory this was unnecessary, as also was the view advocated by Rodger and by Traube that the solute was directly combined with one or more molecules of the solvent. The mere presence in the surface of the solution of molecules of the solute which could not enter the membrane was sufficient to check the escape of solvent particles from the solution into the membrane, without affecting the reverse passage of solvent from the membrane into the solution. This would lead to a diminished solubility on the side of the solution and to a flow of liquid through the membrane which could only be checked by putting pressure on the solution.

The simplest case of a semi-permeable membrane is undoubtedly to be found in the surface of separation between liquid and vapour. At such a surface the kinetic theory postulates a continual interchange of molecules between the two phases. But whilst the rate of escape or evaporation would be reduced by the presence of non-volatile molecules in the surface, the rate of condensation would be unaffected, and equilibrium could only be restored by decreasing the vapour pressure and so diminishing the rate of condensation at the surface of the solution. In this case a quantitative relationship could be deduced. If  $N$  and  $n$  were the relative numbers of particles of solvent and solute in the surface and  $p$  and  $p^s$  the vapour pressures of solvent and solution, then if each molecule of solute replaced a single molecule of solvent in the surface layer, the reduction of vapour pressure would be shown by the equation  $\frac{p^s}{p} = \frac{N}{N+n}$ . It had been shown by Nernst that from this simple relationship the identity of the osmotic pressure of a dilute solution with the pressure exerted by a gas of equal molecular concentration could be directly deduced. The blocking of the surface was, therefore, sufficient to afford, not merely a qualitative, but also a quantitative explanation of osmotic pressure.

The further discussion of the surface structure of liquids as related to the osmotic phenomena will be printed in the *Transactions*.

**Professor L. Kahlenberg** sent in a communication to the discussion on "The Bearing of Actual Osmotic Experiments upon the Conception of the Nature of Solutions."

The occurrence of osmosis and its direction and extent are determined by the nature of the septum and of the liquids that bathe it. Experiments have shown, too, that there is always a major and minor current present, following in opposite directions, although it often appears as if the osmotic process were one-sided. In this case the septum is termed "semi-permeable," and recent research has centred around so-called semi-permeable membranes which really do not exist. The author has demonstrated that it is peculiarly strong selective action on the part of the septum which causes it to be approximately semi-permeable in certain cases, and he has recently even succeeded in separating two colloidal substances by dialysis. This selective action is due to the solubility or insolubility of the substances concerned in the membrane, and therefore osmotic pressure is due to the same forces—essentially chemical in character in the opinion of the author—as the process of solution, and they may be quite variable as different septa and different liquids are employed. The usually accepted "sieve theory" is untenable, because larger molecules frequently go through a membrane more readily than smaller molecules.

So-called semi-permeable membranes have of late years been studied on

account of their bearing on van't Hoff's "gaseous pressure" theory of solution and of osmotic pressure. This maintains that as long as the membrane is semi-permeable the osmotic pressure is the same in the case of any septum for a given solution against the pure solvent, a position contrary to experimental facts.

Again, by applying Carnot's cycle and the usual thermodynamic formulæ to the hypothetical case of abstracting, and then returning solvent from a dilute solution in a cylinder fitted with a semi-permeable piston, relations have been deduced between latent heats of fusion and freezing points, and latent heats of vaporisation and boiling points, assuming the gas equation to hold for dilute solutions. But the results obtained are frequently far from the experimental values found for different solutes in the case of one and the same solvent (in the case of electrolytes), and it has been necessary to postulate either dissociation or polymerisation; but the author, referring to his previous papers, considers these explanations are weak and unnecessary. The thermodynamic calculations involve the assumption of a semi-permeable membrane which at the same time is quite passive. As it is selective action which produces semi-permeability, no such membrane can exist. Therefore, thermodynamic osmotic pressure (which is not really osmotic pressure at all) is quite a different thing from that measured by experiment. Finally, to speak of the experimental osmotic pressure of any solution, without mentioning what septum is used to separate that solution from what other liquid, is devoid of meaning.

**Mr. H. N. Morse** communicated tables containing a summary of the recent experiments, the results of which are about to be published, made by him and Mr. Frazer, with glucose and cane-sugar. The conclusions arrived at are: (1) In the vicinity of  $20^{\circ}$  the osmotic pressure exerted by either is equal to that which a molecular equivalent quantity of a gas would exert if its volume were reduced, at the same temperature, to the volume of the solvent in the pure state. (2) Between  $18^{\circ}$  and  $26^{\circ}$ , at which the measurements were made, both cane-sugar and glucose in solution are in the anhydrous condition. Measurements made just above  $0^{\circ}$  yield pressures somewhat above the calculated gas pressures. Measurements with electrolytes are about to be made in which osmotic pressure and dissociation will be determined simultaneously.

**Dr. J. C. Philip** thought, with reference to Dr. Lowry's hypothesis, that whatever views might be entertained as to the nature of osmotic pressure, one was bound, on thermodynamic grounds, to conclude that dilute solutions must behave as a gas in relation to concentration and temperature.

**Mr. J. G. A. Rhodin** remarked on the fact that osmotic pressure as usually explained seemed to work in the wrong direction, namely, from the lower in the direction of the higher pressure. It was remarkable, too, that a semi-permeable membrane should conduct electricity so easily. Many of the supposed agreements between calculated and observed results and modern physical chemistry were due to a reckless and unjustifiable use of the method of least squares.

**Dr. Alexander Findlay** said that on account of unfamiliarity with van't Hoff's theory of solutions there had been much misunderstanding as to what was the problem actually to be investigated. Referring to Kahlenberg's objection to semi-permeable membranes, from the thermodynamic standpoint it did not matter whether there were selective absorption or not, provided the changes in energy were equal in opposite directions. He considered that the quantitative side and the thermodynamic side of the subject had been thoroughly worked out, and the remarkable accuracy of the work of Morse

and Frazer, and Berkeley and Hartley, pointed to absolute agreement between experiment and the van't Hoff thermodynamic theory. He did not take kindly to Dr. Lowry's kinetic explanation, and thought that the membrane might be left out altogether, and the diffusion only between a solution and a layer of pure solvent on the top of it made use of for explaining what took place.

**Mr. W. A. Davis** said that van't Hoff's original hypothesis neglected the influence exerted on the solute by the solvent; Dr. Lowry's modification of van't Hoff's conception was therefore necessary from that standpoint. Osmotic pressure had also been explained as the tendency to equalise the surface tension on the two sides of the osmotic cell.

**The Earl of Berkeley** disagreed with Dr. Findlay that the thermodynamic was the only logical way of looking at things. He discussed further the discrepancy between the formula used by him and the thermodynamic formula which could be explained on the conception one formed of osmotic pressure.

**Dr. T. M. Lowry** said that the views he advocated accounted for the negative direction of the osmotic flow referred to by Mr. Rhodin. It was not remarkable that Boyle's law should hold good for osmotic pressure, but it was remarkable that the constant  $R$  in the two cases should be identical. The agreement should throw light on the surface structure of liquids.

**The Chairman** emphasised the general applicability of the vapour-pressure method, which, although tedious and troublesome, could be used with any solvent, at all temperatures, and under all pressures. The compressibility of liquids would prevent it agreeing quite with direct measurements; it was therefore important that careful comparisons of the two should be made. In reply to Dr. Findlay, Morse and Frazer's results did not agree with those of Berkeley and Hartley; there was a possible constant error in the former, in spite of the extraordinary accuracy of the work. He hoped more experimental work would be done with living tissues on the line of Pfeffer's original measurements. The term "osmotic pressure," unless merely used in the sense of a pressure required to establish equilibrium, was a misleading one; there was nothing to show that a pressure existed inside a solution in a closed vessel apart from simple gravity pressure. The results of Morse and Frazer brought dilute and concentrated solutions into line, and were a great advance on the van't Hoff treatment; they put the ordinary gas point of view quite out of court. He deprecated the dogmatic, unscientific treatment to which the whole subject had been subjected for the purpose of bolstering up a particular point of view: the facts needed examination from a broad and critical standpoint.

A vote of thanks, moved by the **Chairman**, was accorded with acclamation, to the **Earl of Berkeley** for having exhibited his apparatus, and to Mr. Whetham, Dr. Lowry, Professor Kahlenberg, and Mr. Morse for the contributions they had made to the discussion.

The authors reserved their full replies for the printed discussion in the *Transactions*.

## OFFICIAL NOTICES.

The next **Ordinary Meeting** of the Society will be held on Tuesday, February 19, 1907, at the Institution of Electrical Engineers, 92, Victoria Street, London, S.W., when **Mr. John B. C. Kershaw** will read a Paper on "The Present Position and Future Prospects of the Electrolytic Alkali and Bleach Industry."

## ORDINARY MEETINGS.

As far as can be arranged, the Ordinary Meetings of the Society will in future be held either on the second or third Tuesday in the month.

The Council invites Members who are willing to show experiments or exhibit apparatus at the meetings of the Society to communicate with the Secretary.

## CHANGES OF ADDRESS.

|                                   |                                                  |
|-----------------------------------|--------------------------------------------------|
| ACKER, C. E.                      | 148, Gluck Building, Niagara Falls, N.Y., U.S.A. |
| FERRANTI, S. Z. de                | Grindleford, Sheffield.                          |
| MCCORMICK, CAPTAIN A. L. C., R.E. | 82, Elshoner Road, Kensington, W.                |
| SELIGMAN, R. J. S.                | 33A, High Street, Kensington, W.                 |

## NEW MEMBER.

|                               |                                       |
|-------------------------------|---------------------------------------|
| PACKER, CHARLES HENRY, F.C.S. | Merrill's House, Wednesfield, Staffs. |
|-------------------------------|---------------------------------------|

## TRANSFERRED FROM STUDENT TO MEMBER.

|                           |                                    |
|---------------------------|------------------------------------|
| PREBBLE, WILLIAM CLARENCE | 196, Adelaide Road, Brockley, S.E. |
|---------------------------|------------------------------------|

## NEW STUDENT.

|                                   |                                             |
|-----------------------------------|---------------------------------------------|
| CUMMING, ALEXANDER CHARLES, D.Sc. | 9, Marlborough Hill, Wealdstone, Middlesex. |
|-----------------------------------|---------------------------------------------|

## BOOKS RECEIVED.

*(Books of special physicochemical or electrochemical interest will be reviewed in the Transactions.)*

**The Manufacture of Metallic Articles Electrolytically: Electro-Engraving.** (Knapp's Monographs on Applied Electrochemistry.) By Dr. W. PFANHAUSER. Authorised English Translation by Professor JOSEPH W. RICHARDS, M.A., PH.D. (Easton, Pa., U.S.A., 1906: The Chemical Publishing Company. Pp. 159. \$1.25.)

CONTENTS:—Historical; Baths for Copper Galvanoplasty; Physical Properties of the Copper Deposit; Behaviour of Copper Anodes; Constants and Calculations; Industrial Plants; Special Devices: Production of Uniform Deposits; Manufacture of Metallic Powders and Metallic Foil; Production of Wire; Manufacture of Bodies of Large Size; Parabolic Reflectors; Tubes; Electrolytic Etching and Engraving; Tables.

**Practical Physical Chemistry.** By ALEXANDER FINDLAY, M.A., PH.D., DSc. (London, 1906 : Longmans, Green & Co., 39, Paternoster Row, E.C. Pp. 282. Price 4s. 6d.)

CONTENTS:—Calculation of Results and Errors ; Weight and Volume ; Densities of Liquids and Gases ; Thermostats ; Viscosity and Surface Tension ; Optical Measurements ; Molar Weight of Substance in Solution ; Distribution of a Substance between Two Non-miscible Solvents ; Conductivity of Electrolytes ; Transport Numbers ; Measurement of E. M. F. ; Velocity of Chemical Reaction in Homogeneous Systems ; Thermo-Chemistry ; Solubility ; Transition Points.

**Die Elektrochemie im Jahre, 1905.** By D. H. BORN.

Reprinted from *Die Chemische Industrie* (Weidmannsche Buchhandlung, Berlin).

**The Treatment of Storage Batteries.** By R. W. VICARY. (London, 1907 : The Electric Accumulator, 15, Queen Street, E.C. Pp. 58. Price 2s. 6d. net.)

**Revue de L'Électrochimie et de L'Électrometallurgie.** Part I., January, 1907. (1, Boulevard Saint Germain, Paris. Price 2 fr. 50 the number, 30 fr. annually.)

This is the first issue of a well got up new French monthly review devoted to electro-chemistry and electrometallurgy. Its forty pages of reading matter contain serial articles by M. Jouve on "The Electrochemical Manufacture of Nitric Acid from the Air," M. Minet on "The Electric Furnace in Laboratory and Industry," and on "Physico-Chemical Constants"; short articles by R. Goldschmidt on "Electrolytic Interruptions," by Broca and Turchini on "The Resistance of Electrolytes for High-frequency Currents"; and finally the usual Notices, References, Reviews, and Abstracts of Articles and Patents.

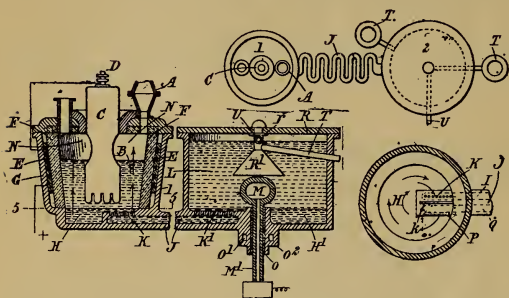
## ABSTRACTS OF PATENTS

### RELATING TO ELECTROCHEMISTRY AND ELECTROMETALLURGY.

*Specially compiled by MESSRS. G. F. REDFERN & Co., Chartered Patent Agents, of 4, South Street, Finsbury, E.C.; and 21, Southampton Buildings, London, W.C.*

#### BRITISH SPECIFICATIONS PUBLISHED.

**The Electrolysis of Metallic Compounds or Ores.**—E. A. ASHCROFT, of Murray Hill Hotel, New York, U.S.A. No. 26,813 of 1905. Relates to electric

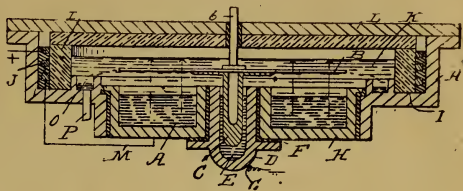


furnaces in which the electrolyte and liquid cathode are caused to swirl and circulate by the magnetic action produced by a transformer coil through which the current passes. The chief features of the invention are a regenerative passage which connects the two parts of the furnace, and a cathode of special

form for collecting the metal in the producing cell. The process is described with reference to the manufacture of sodium: Common salt is charged into the furnace at *A* and is fused at *B*. *H* is an alloy of sodium and lead. The current on its way to the anode *C* passes through the coil *E* surrounding the magnesia lining *F*, and so sets up a strong magnetic field in the iron casing *G*, the lines of force tending to pass in the direction indicated by the arrows, whilst the lines of current flow nearly at right angles, and so cause a motion of the metal again at right angles. The rotation of the liquid is taken advantage of to cause it to pass through holes *K* into one side *I* of a sinuous pipe *J*, and so into the producing vessel 2. A reflux of metal is also induced from the cell 2 through holes *K'* into the other side *Q* of the pipe *J*, and then back to the cell 1. By this means heat is transferred to the returning metal in the passage *Q* from the outgoing metal in passage *I*, so that whilst the contents of cell 2 are brought to the correct temperature the heat of cell 1 is not wasted. The liquid cathode of cell 1 becomes the anode of cell 2, the cathode of the latter being a globular shell *M*, upon which the sodium is deposited. As the metal is detached by gravity it rises into the collecting bell *R*, in electrical contact with the cover *R*, whence it is drawn through the pipe *U*, and so preserved from contact with the air. The restricted area of contact of the sodium with the caustic reduces the corrosive action of the latter to a minimum. By the action of the sodium, however, the caustic is gradually reduced in efficiency, and to renew it tanks *T* are provided where it is exposed to the air to absorb water. The working temperature of cell 1 is about 700° C., and in cell 2 about 330° C., when common salt is used.

**Process and Apparatus for Electrolysis of Alloys, Fused Salts, Solutions, Ores, or Chemical Compounds.**—E. A. ASHCROFT, of Murray Hill Hotel, New York, U.S.A. No. 146 of 1906. This invention is applicable when the cathode of an electrolytic cell is required to rotate—for example, in the refinement or separation of metals by fractional electrolysis,

the production of homogeneous deposits of solid metal by the aid of skin friction of the electrolyte, the maintenance of a stirring action in the cell for keeping the solid particles in suspension, the continuous removal by centrifugal or centripetal action of heavy metals deposited on the cathode and in certain electrochemical processes in which separation of the products is effected by centrifugal or centripetal action.



The invention is described with reference to the refinement of silver-lead bullion, which is here the anode *A*. The cathode is a disc *B* of steel, carried by a trunnion *C*, floating upright in fused metal *E*, contained in a pocket *D*, and insulated at *F* from the anode portion of the cell with which it may be connected at *G*. The cast-iron or steel container *H* has a refractory lining *I* of silicious clay or magnesia bricks, and may extend into the molten metal to protect the cell-body from electrolysis. Behind the lining *I* is a coil *J*, set in insulating cement. *L* is an iron or steel cover. The electrolyte *K* may be fused lead, chloride, bromide, iodide, or other suitable salt. The fused alloy *A* of lead, gold, and silver is supplied through a passage in the lower part of the cell *H*. The current, entering at *M*, leaves the surface of the alloy, traverses the electrolyte and deposits lead on the cathode *B*, at the same time dissolving an equivalent of the metal from the anode *A*, and traverses the disc *B* radially, leaving through trunnion *C* and terminal *G*. Lines of magnetic force are set up in the metal circuit *L*, *H*, as indicated by the arrows, and these, cutting the radial lines of current-flow in the disc *B*, cause the latter to rotate rapidly. The collection of the pure metal from the underside of the disc *B* is effected by drawing it from a channel *O* into which it is thrown by centrifugal force. When the metal deposited is lighter than the electrolyte it will tend toward the centre, and may be made to mount an outlet conduit; or vanes are sometimes employed to conduct the metal to the centre.

**Electric Furnaces.**—C. BINGHAM, of 11, Queen Victoria Street, London. No. 7,340 of 1906. The invention refers to furnaces having one or more bottom electrodes and a plurality of top electrodes, and the object is to render such furnaces more efficient in working without interfering with the electrodes. The upper electrodes are all of one sign and the lower have the opposite sign. Regulation is effected outside the furnace. If a transformer is used, portions of the primary or secondary may be cut out or in, or if an alternating generator is used, portions of the exciter coils may be similarly operated to vary the voltage. Such an arrangement is very suitable for use with poly-phase currents, since the electrodes can be divided into groups corresponding with the number of phases and each phase used to operate a separate group.

**Manufacture or Treatment of Iron or Steel.**—E. F. COLBORN, of Popperton Place, Salt Lake City, Utah, U.S.A. No. 15,626 of 1906. Relates to a method of treating ordinary low-grade Bessemer or "mild" steel so that its toughness or tensile strength is greatly increased. Bars of such metal, for example, are plunged red-hot into a given solution and a low-tension electric current is then passed through the solution and metal during

the treatment. This appears to hasten the action of the solution and is very desirable where the bars are thick.

**Production of Ornamental Metal Articles.**—S. O. COWPER-COLES, of Grosvenor Mansions, Victoria Street, Westminster. No. 5,745 of 1906. According to the invention a mould in wax is made of the shape of the article to be produced, and the portions of the design intended to be thrown into relief are surrounded by a line incision of sufficient depth to contain enamel, glass, or like composition. The mould is then made electrically conductive and an electrotype, having the surrounding line in relief, is taken from it. This electrotype is then used as a "stripping" or "tear" mould for the production of further electrotypes. The latter, having the sunk outlines, then have metal deposited on those parts designed to have a colour differing from their bodies, which may be copper, for example. This deposition may be effected by baking in zinc or other suitable dust. The sunk outlines are finally filled up with coloured enamel, or other composition of low melting point, so as to throw the design into relief.

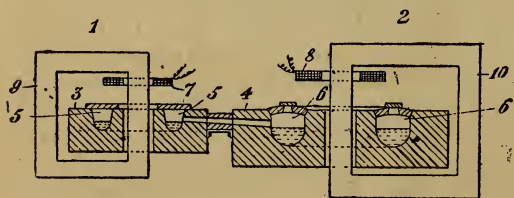
**Electrodeposition of Copper and other Metals.**—S. O. COWPER-COLES, of Grosvenor Mansions, Victoria Street, Westminster. No. 8,924 of 1906. The invention relates to the electrodeposition of metals from solutions which have to be maintained in an oxidised state, as, for example, the deposition of copper from a cupric solution. To this end the solution is projected by centrifugal force in the form of a fine spray, this being advantageously effected by passing it through an atomiser having rotating vanes or wheels which throw off the solution in a finely divided state. Where crude anodes are used in the deposition of copper the solution contains much foreign matter in suspension, and, therefore, in addition to passing through an atomiser, it is also passed through a large tank containing broken granite or felspar of varying size. This arrangement also allows the release of air retained by the solution after aeration. The inventor finds that a strong light, such as daylight or the arc light, clarifies the solution, and he therefore subjects it to such light or lights at any time during aeration or separation.

**Method of and Furnace Plant for Reduction of Ores or the like by Electric Transformer-Furnaces.**—O. FRICK, of Saltsjöbaden,

Sweden. No. 10,097 of 1906.

In the reduction of ores, melting of metals, &c., the melting of the charge and the treatment following have hitherto been accomplished in the same furnace, the material having formed a conductor of

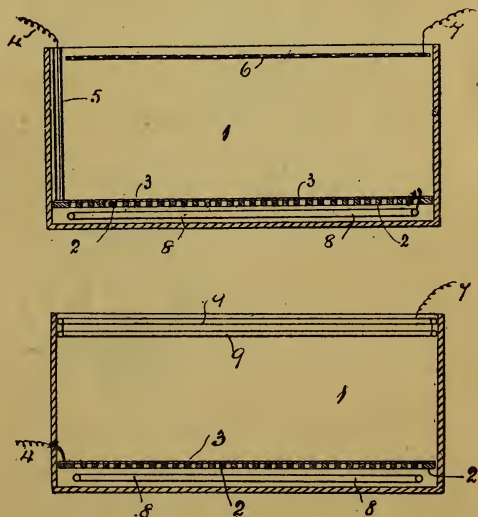
nearly constant cross-section. The method suffers, however, from a great disadvantage: it is difficult to treat large charges, the self-induction and lag being very considerable and becoming the greater the larger the charge—*i.e.*, the cross-section of the melting bath. The object of the invention is to render it suitable to treat any size of charge by means of transformer-furnaces, and the invention consists in the construction of two separate transformer-furnaces and the carrying out of the treatment in them, the first



being constructed for a comparatively small charge and great consumption of energy for melting, while the second is constructed for large charges and small consumption of energy for storing up the melted materials and keeping them heated. The favourable influence on the power factor in the primary circuit will be easily understood by an example. Supposing the angle of lag be  $\tan \psi = c \cdot \sim \frac{1}{r} \left( \frac{1}{Wp} + \frac{1}{Ws} \right)$ ; if the influence of the magnetisation current of the transformer be dispensed with and the ampere-turns of the primary winding be supposed to equal those of the bath. In this equation  $c = \text{constant}$ ,  $\sim = \text{frequency per second}$ ,  $r = \text{resistance of the melting-bath in ohms}$ ,  $Wp = \text{magnetic resistance of the primary flux of leakage}$ ,  $Ws = \text{magnetic resistance of the secondary flux of leakage}$ . If, for instance, a transformer-furnace is used for melting steel with a charge of 15 tons, and supposing the cross-section of the melting bath be constant, the lag, for instance, at 25 periods a second  $= \cos \psi = 0.20$ ; that is to say, the primary winding of the furnace, the wires, and the generator must be calculated for  $\frac{1}{0.2} = \text{five times the real power}$ . Further advantages are gained over single transformer-furnaces. By combining two furnaces continuous working is possible in cases where the melted material requires a certain time for refining, or where materials of different composition are to be produced after each other—for instance, alloys of steel. 1 is the smaller furnace in which the melting process proper is accomplished, and from which the melted material continually flows. 2 is the larger furnace, serving as refining furnace and storer, until the old charge is ready. 3 and 4 indicate masonry of suitable material. 5 and 6 are the ring-shaped crucibles. 7 and 8 are the primary windings supplied with alternating current from the same source of current or from two separate sources. 9 and 10 are the magnet cores.

**Method and Apparatus for treating Textile Fibrous Materials with the Products of the Electrolysis of Water Solutions of Acids, Oxides, and Salts.** — H.

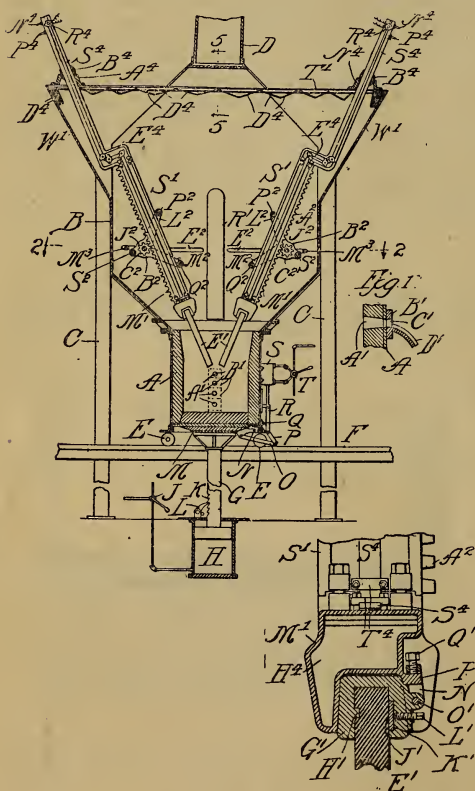
HEY, of 2, Ash Terrace, Savile Town, Dewsbury. No. 2,083 of 1906. The object of this invention is to prevent the chemically opposite products at the electrodes from mixing and neutralising each other, thus keeping them in a separate active condition during the operations of cleansing, bleaching, carbonising, dyeing, stripping, and sterilising fabrics. Each vat 1, for containing the material and solutions, is provided near the bottom with a grid 2 of suitable material covered on one or more surfaces with a lead or other metal conductor 3 and connected with a source of electric energy by the insulated conductor 4. The upper electrode is a



similar grid 6 connected with the current source at 7. On the passage of current gases liberated at 6 escape into the air, whilst products from electrode 3 diffuse through the fibrous material, or combine with the constituents of the bath to form new compounds which readily act on the fabric. Preferably the switch is arranged so that the direction of current may be reversed and either form of product liberated at the bottom. The electrodes are thus kept cleaner than when the current always passes in one direction. Instead of, or in addition to, the suitable acids, substances are used which are capable of absorbing or liberating a definite quantity of energy in passing from one stage of combination to another, such as the oxides of chromium, vanadium, manganese, titanium, iron, copper, etc. The energy is supplied by the current, but the graduated application is fixed by the nature of one or more of the intermediary substances. Circulation and the cleaning or other operation may be assisted by a steam coil 8, whilst cooling may be effected quickly by cold water coil 9, the latter, if desired, being used as the upper electrode.

**Electric Furnaces.**—H. L. HARTENSTEIN, of Constantine, Mich., U.S.A. No. 10,156 of 1906. According to this invention, the furnace chamber A is

carried by wheels E on a track F, and when in position under the hopper B is retained by means of a hydraulic plunger G, having ratchet teeth *k* engaged by a pawl L. The hearth of the furnace is hinged to the chamber A, and is operated by means of a hydraulic piston R and system of levers O when required. The product, slag, &c., is tapped off at A'. The electrodes E' are carried in blocks G', having straps N' and screws by which they can be secured in place in the head M'. Several carbons are carried in the head side by side, and by turning down its strap N' any one may be removed from the head M'. This head is hollow, and water may be circulated through it for cooling purposes. The electrodes E' are adjustable vertically by means of rack teeth engaging pinions J' fast on shafts that can be rotated by means of worm-wheels, the worms being operated by



hand-wheels. Lateral adjustment is effected by turning the guides L', M' about their common centre by means of sleeves to which they are attached and which have wheels fast on them with engaging worms operated by hand-wheels. The upper ends of the carbon-holders slide through insulating

blocks B<sup>4</sup>, which are journaled at the sides, whilst the air is excluded from the upper part by means of the jointed curtain D<sup>4</sup>, whatever the position of the electrodes. The offset E<sup>4</sup> is provided to allow the holders to clear the stack D when the electrodes are in the vertical position. The furnace is charged through the hopper R<sup>4</sup>.

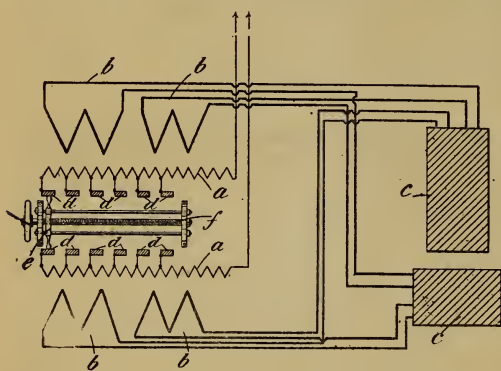
**Removal of Metal Plating or Coating from Metallic or other Surfaces.**—W. R. HODGKINSON, of 18, Glenluce Road, Blackheath. J. H. HARDCASTLE, of 70, Burnt Ash Road, Lee, and A. H. COOTE, of 36, Humber Road, Westcombe Park, all in Kent. No. 717 of 1906. The object of the invention is, chiefly, to effect the removal of copper, nickel, or zinc from iron or steel surfaces. The plated article is brought into contact with an ammoniacal solution in conjunction with a metal block, so that when connected with a source of electricity they form an electric couple. To remove the copper coating from the "lands" and "grooves" of a gun without injury to its steel surface, a metal pole-piece is inserted in the bore and insulated from it, then the gun is inclined suitably and filled with the following liquid: 2 per cent. best glacial acetic acid; 15 per cent. ammonia, 0.88 sp. gr; 83 per cent. water. The gun and pole-piece are then inserted in an electric circuit, and a current of, say, 100 amperes at 5 to 10 volts sent through it, then the copper leaves the gun-bore and is deposited on the cathode pole-piece.

**A Process for Obtaining Metals from Ores or Furnace Products in the Electric Furnace.**—Dr. K. KAISER, of 10, Meierottostrasse, Berlin, W., Germany. No. 15,818 of 1906. By this invention ores of volatilisable metals such as zinc are smelted in an electric furnace and the metal obtained in the liquid state. The process consists in melting the ore or furnace product, with any required aid to fusion but without reducing agents, in an electric furnace and blowing into the molten mass a reducing gas such as that made by passing heated air over white-hot coal or water gas. If zinciferous roasted pyrites are thus treated the zinc is quickly evolved as metal with small energy consumption, the molten iron remaining. The furnace may be of either the resistance or of the arc type. Sulphide ores need not be first roasted; they may be heated in the furnace in a current of air to oxidise them and then in the reducing gas.

**Electrolytic Process for the Treatment of Copper Ores and Copper Waste for the Recovery of Pure Copper.**—L. M. LAFONTAINE, of 3, Rue Albouy, Paris, France. No. 2,989 of 1906. The electrolyte in this process is made as follows: A quantity of water, say 4,000 litres, is introduced into the vat, and 10 per cent. by weight of sulphuric acid mixed with it. In the liquid is then suspended a bag containing 10 kilos of barium bixide (BaO<sub>2</sub>), which in the presence of acid and water is decomposed and forms oxygenated water. After twenty-four hours' rest, sulphate of copper is introduced up to saturation, 16° to 20° Baumé. When the liquor has settled,  $\frac{1}{2}$  per cent. of the weight of the water in lamp-black is added to it to ensure conductivity and hasten deposition. This solution is so prepared that the acid combination is the first to be decomposed by the current and metals, other than copper, enter into combinations of higher potential and are not decomposed. The vats used are intended to secure the maximum of electrodes for the minimum of electrolyte, the dimensions adopted being 3 by 1.10 metres high and 30 cm. wide, to contain about 4,000 litres of electrolyte. The anodes are formed, in part, of rattan, being baskets 0.6 cm. wide, 1.05 metre deep, and 1.25 metre

wide, each containing about 25 kilos of ore, and each having a triangular rod of copper to ensure conductivity, and by which it is suspended. The ore is crushed as fine as possible after washing in water. The dust and concentrates from mining operations, containing copper usually lost, may be treated with advantage by this process. These are mixed with unslaked lime in the proportion of 80 per cent. powder to 20 per cent. lime, and moulded to a thickness corresponding with the baskets. To ensure conductivity, a trellis of copper wire is embedded in the mass, which thus becomes a reinforced slab. These anodes contain 10 to 25 per cent. of copper easily decomposed by reason of their porosity. The copper is first decomposed to form a copper salt, the iron being the last attacked by the acid base to form insoluble ferric oxide which cannot affect the electrolysis. Lead remains insoluble and falls as dust. Silver and gold are precipitated by the solution and can be collected for treatment by known methods.

**Electric Furnaces.**—C. E. PETTIT, of 72, Alleyn Road, West Dulwich, London, S.E. No. 131 of 1906. It is well known that the voltage of electric



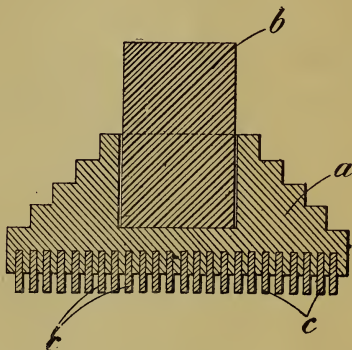
furnaces varies considerably according to the material under treatment, and it is essential, in order to obtain the best results, that this potential difference may be adjustable by hand, in order to meet the differing requirements. According to the invention, a voltage regulator is placed between the transformer and the terminals of the furnace, where transformers are used, or on the exciter of

the generator, where an alternating current generator is connected directly with the furnace. Where continuous current is employed the regulator may be connected with the generator in any suitable manner. The first case is illustrated. *a* is the high-tension coil of the transformer, the secondaries *b, b* of which are coupled to the electrodes *c* of the furnace. The primary *a* is split into sections, varying preferably by 2 volts, and coupled through contact pieces *d*, over which an arm *e* may be moved by a screw *f* to cut in or out one or more sections. Thus, with a normal potential of 50 volts the difference might be decreased to 40 by steps of 2 volts, or increased to 60 in the same manner.

**Method of Precipitating Metals Electrolytically.**—A. RAMÉN, of Helsingborg, Sweden. No. 18,080 of 1906. The present methods of precipitating metals from solutions of salts, produced from calcined ores, all require a great expenditure of energy, due to the difficulty of maintaining a low difference of potential between the anode and cathode. Whilst depolarising anode liquids have been used in baths with two cells, none has succeeded perfectly in maintaining a steady low potential, because the composition of the anode liquid could not be kept constant. According to this invention, a portion of the solution from which the metals are to be precipitated is taken and the copper removed by means of iron. The resulting lye, being a

solution of ferro-salts, is used as the depolariser in the anode compartment, and is oxidised when acted on by the current. Thus a practical use is now found for this lye, hitherto a troublesome waste product—*i.e.*, in reducing the consumption of energy required for the electrolysis. The rest of the solution is run into the cathode chamber, and from it the metals, beginning with the most electro-negative, are precipitated. The anode lye, as above described, may be concentrated to any desired degree, and in this way the required difference of potential may be arranged for. Any waste solution from which the copper has been precipitated by means of iron may be used as a depolariser, instead of a treated part of the cathode electrolyte.

**Electric Furnaces.**—C. E. PETTIT, of 72, Alleyn Road, West Dulwich, London, S.E. No. 132 of 1906. In order to evade the difficulty arising from the faulty connection of the lower electrode in furnaces used in the production of calcium carbide, or the like, the inventor embeds this electrode in a block *a* of cast iron for about half its length, ensuring a good contact by cementing them together by a mixture of tar and powdered carbon. The block *a* is stepped to form a convenient bed upon which to construct the masonry of the furnace. In the bottom of the block a number of grooves are planed or otherwise formed, and into these the copper conductors *c, c*, which fit tightly, are driven so as to provide a plurality of independent connections.



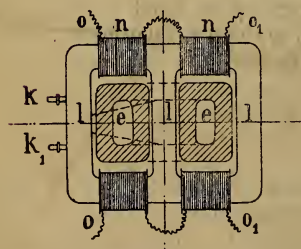
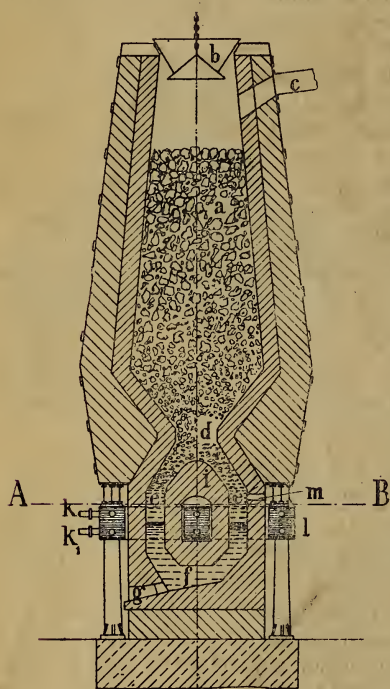
**Matrices for Use in the Galvano-Plastic Process.**—H. SCHIMANSKY, of Zoppot, Germany. No. 8,843 of 1906. In order to reduce the amount of pressure required to force the lead matrix, as at present used, into contact with the surface of the original to be copied, according to this invention a layer of thin lead about as thick as silk paper is used next the original; next that are placed two similar lead layers, each coated with a mixture of 60 parts bees' wax, 20 parts asphalte dissolved in turpentine, and 20 parts of Venetian turpentine. The matrix plate thus prepared is pressed into contact with the original, and is stated to penetrate the finer recesses of its surface most efficiently. If the original is large, a lead backing of about 1 mm. thickness is pasted on the pressed matrix and painted with an insulating composition. A backing of millboard is then placed upon this and the whole again pressed to combine the strengthening plate with the high reliefs at the back of the mould.

**Production of Technically Pure Ductile Tantalum.**—SIEMENS AND HALSKE AKTIENGESELLSCHAFT, of 3, Askanischer Platz, Berlin, Germany. No. 14,062 of 1906. The process of producing, by means of the electric current, a mixture of tantalum and hydrogen, a brittle metallic body, is already well known, and according to the invention this product is heated above its melting point in a vacuum, all separated gas being immediately withdrawn by an air-pump so that recombination cannot take place.



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**Manufacture of Decarburised Cast Iron.**—SOC. ELECTRO-METALLURGIQUE FRANÇAISE, of Froges, Isère, France. No. 13,189 of 1906. According to the invention a charge of molten cast steel is systematically cooled until it is wholly or partially solidified, or it may be below solidification temperature. As the molten metal cools crystals of ferrite form, and the liquid mass, forming a mother-liquor, becomes richer in foreign elements, notably carbon. When the concentration of these elements increases the oxide of carbon and other gases escape, and the metal may be remelted and cast in moulds. Deoxidants such as aluminium may be added. The operation is preferably conducted in an electric furnace, where the metal can be protected from carburising action and where any required variations in temperature may be provided for.



**Method of Obtaining Metals from their Ores, or for Heating Substances in Electric Furnaces, and Electric Furnaces for Use therewith.**—N. A. WALLIN, of Kantstrasse 159, Charlottenburg, Germany. No. 12,395 of 1906. In the transformer furnace as at present constructed the tendency of the induced current is to follow the course of least resistance through the material being treated, that is, through the better conducting, and in the case of ore, molten portion. By this invention the induced current is compelled to pass through a portion of the unsmelted ore. The smelting portion is in the form of a vertical ring e, around and through which pass the limbs l of the primary core. The portion of the unreduced ore at d offers far greater resistance to the passage of current than the metal f, or the mixed ore and metal about the line A, B, and the energy is thus expanded on those portions most requiring it. Modifications in the construction are described. In one the ring e is inclined to the vertical. In a second the furnace is carried on wheels and a tapping-off chamber provided. In another the collector is connected with the smelting chamber by a neck adapted to be continuously heated, whilst in another the section of the ring-space e is varied so as to obtain greater resistance through the molten portion of the charge, which can thus

be removed in a thoroughly smelted condition.